

Project 2.2 Report

In this report I have experimented on the classifiers AODE, BayesNet, and NaiveBayes, as well as with Neural Networks like Winnow, VotedPerceptron, and MultilayerPerceptron. The test option is on cross-validation of 10 folds. The weather file I used is normalized. Detailed explanation of what they are according to the WEKA API is the following:

AODE:

AODE achieves highly accurate classification by averaging over all of a small space of alternative naive-Bayes-like models that have weaker (and hence less detrimental) independence assumptions than naive Bayes. The resulting algorithm is computationally efficient while delivering highly accurate classification on many learning tasks.

BayesNet:

Base class for a Bayes Network classifier. Provides datastructures (network structure, conditional probability distributions, etc.) and facilities common to Bayes Network learning algorithms like K2 and B. Works with nominal variables and no missing values only.

NaiveBayes:

Class for a Naive Bayes classifier using estimator classes. Numeric estimator precision values are chosen based on analysis of the training data. For this reason, the classifier is not an UpdateableClassifier (which in typical usage are initialized with zero training instances)

I ran these classifiers against the attribute "Play" for either "yes" or "no".

=== Run information ===

Scheme: weka.classifiers.bayes.AODE -F 1

Relation: weather.symbolic

Instances: 14

Attributes: 5

outlook

temperature

humidity

windy

play

Test mode: 10-fold cross-validation

=== Classifier model (full training set) ===

The AODE Classifier

Class yes: Prior probability = 0.63

Class no: Prior probability = 0.38

Dataset: weather.symbolic

Instances: 14

Attributes: 5
Frequency limit for superParents: 1
Correction: laplace

Time taken to build model: 0 seconds

=== Stratified cross-validation ===

=== Summary ===

| | | | |
|----------------------------------|---------|----|---|
| Correctly Classified Instances | 7 | 50 | % |
| Incorrectly Classified Instances | 7 | 50 | % |
| Kappa statistic | -0.0426 | | |
| Mean absolute error | 0.4706 | | |
| Root mean squared error | 0.498 | | |
| Relative absolute error | 98.8198 | % | |
| Root relative squared error | 100.941 | % | |
| Total Number of Instances | 14 | | |

=== Detailed Accuracy By Class ===

| | TP Rate | FP Rate | Precision | Recall | F-Measure | ROC Area | Class |
|---------------|---------|---------|-----------|--------|-----------|----------|-------|
| | 0.556 | 0.6 | 0.625 | 0.556 | 0.588 | 0.533 | yes |
| | 0.4 | 0.444 | 0.333 | 0.4 | 0.364 | 0.533 | no |
| Weighted Avg. | 0.5 | 0.544 | 0.521 | 0.5 | 0.508 | 0.533 | |

=== Confusion Matrix ===

a b <-- classified as
5 4 | a = yes
3 2 | b = no

This classifier, AODE, only have 50% accuracy.

=== Run information ===

Scheme: weka.classifiers.bayes.BayesNet -D -Q weka.classifiers.bayes.net.search.local.K2 -- -P 1 -S BAYES -E weka.classifiers.bayes.net.estimate.SimpleEstimator -- -A 0.5

Relation: weather.symbolic

Instances: 14

Attributes: 5

outlook
temperature
humidity
windy
play

Test mode: 10-fold cross-validation

=== Classifier model (full training set) ===

Bayes Network Classifier

not using ADTree

#attributes=5 #classindex=4

Network structure (nodes followed by parents)

outlook(3): play

temperature(3): play

humidity(2): play

windy(2): play

play(2):

LogScore Bayes: -69.07317135664013

LogScore BDeu: -83.46880542273107

LogScore MDL: -82.71568504897063

LogScore ENTROPY: -65.56181240647145

LogScore AIC: -78.56181240647145

Time taken to build model: 0 seconds

=== Stratified cross-validation ===

=== Summary ===

| | | |
|----------------------------------|-----------|-----------|
| Correctly Classified Instances | 8 | 57.1429 % |
| Incorrectly Classified Instances | 6 | 42.8571 % |
| Kappa statistic | -0.0244 | |
| Mean absolute error | 0.415 | |
| Root mean squared error | 0.4909 | |
| Relative absolute error | 87.1501 % | |
| Root relative squared error | 99.5104 % | |
| Total Number of Instances | 14 | |

=== Detailed Accuracy By Class ===

| | TP Rate | FP Rate | Precision | Recall | F-Measure | ROC Area | Class |
|---------------|---------|---------|-----------|--------|-----------|----------|-------|
| | 0.778 | 0.8 | 0.636 | 0.778 | 0.7 | 0.622 | yes |
| | 0.2 | 0.222 | 0.333 | 0.2 | 0.25 | 0.622 | no |
| Weighted Avg. | 0.571 | 0.594 | 0.528 | 0.571 | 0.539 | 0.622 | |

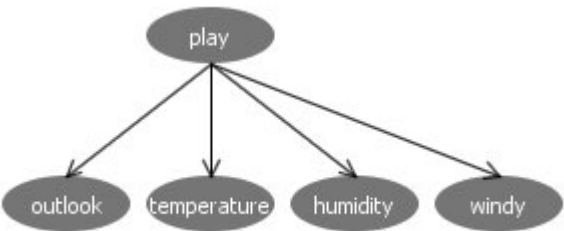
=== Confusion Matrix ===

a b <-- classified as

7 2 | a = yes

4 1 | b = no

The BayesNet classifier only worked slightly better in that it only predicted 1 more than AODE correctly. Below is the graph generated:



Clicking on the nodes yielded the following tables of probability distribution shown:

Play vs. Outlook

| play | sunny | overcast | rainy |
|------|-------|----------|-------|
| yes | 0.238 | 0.429 | 0.333 |
| no | 0.538 | 0.077 | 0.385 |

Play vs. Temperature

| play | hot | mild | cool |
|------|-------|-------|-------|
| yes | 0.238 | 0.429 | 0.333 |
| no | 0.385 | 0.385 | 0.231 |

Play vs. Humidity

| play | high | normal |
|------|------|--------|
| yes | 0.35 | 0.65 |
| no | 0.75 | 0.25 |

Play vs. Windy

| play | TRUE | FALSE |
|------|-------|-------|
| yes | 0.35 | 0.65 |
| no | 0.583 | 0.417 |

=== Run information ===

Scheme: weka.classifiers.bayes.NaiveBayes

Relation: weather.symbolic

Instances: 14

Attributes: 5

outlook

temperature

humidity

windy

play

Test mode: 10-fold cross-validation

=== Classifier model (full training set) ===

Naive Bayes Classifier

Class

Attribute yes no
 (0.63) (0.38)

=====

outlook

| | | |
|----------|------|-----|
| sunny | 3.0 | 4.0 |
| overcast | 5.0 | 1.0 |
| rainy | 4.0 | 3.0 |
| [total] | 12.0 | 8.0 |

temperature

| | | |
|---------|------|-----|
| hot | 3.0 | 3.0 |
| mild | 5.0 | 3.0 |
| cool | 4.0 | 2.0 |
| [total] | 12.0 | 8.0 |

humidity

| | | |
|---------|------|-----|
| high | 4.0 | 5.0 |
| normal | 7.0 | 2.0 |
| [total] | 11.0 | 7.0 |

windy

| | | |
|---------|------|-----|
| TRUE | 4.0 | 4.0 |
| FALSE | 7.0 | 3.0 |
| [total] | 11.0 | 7.0 |

Time taken to build model: 0 seconds

=== Stratified cross-validation ===

=== Summary ===

| | | |
|----------------------------------|-----------|-----------|
| Correctly Classified Instances | 8 | 57.1429 % |
| Incorrectly Classified Instances | 6 | 42.8571 % |
| Kappa statistic | -0.0244 | |
| Mean absolute error | 0.4374 | |
| Root mean squared error | 0.4916 | |
| Relative absolute error | 91.8631 % | |
| Root relative squared error | 99.6492 % | |

Total Number of Instances 14

=== Detailed Accuracy By Class ===

| | TP Rate | FP Rate | Precision | Recall | F-Measure | ROC Area | Class |
|---------------|---------|---------|-----------|--------|-----------|----------|-------|
| | 0.778 | 0.8 | 0.636 | 0.778 | 0.7 | 0.578 | yes |
| | 0.2 | 0.222 | 0.333 | 0.2 | 0.25 | 0.578 | no |
| Weighted Avg. | 0.571 | 0.594 | 0.528 | 0.571 | 0.539 | 0.578 | |

=== Confusion Matrix ===

a b <-- classified as

7 2 | a = yes

4 1 | b = no

Here the NaiveBayes did the same as BayesNet. Both have the same predictions and same confusion matrix.

For the Neural Networks part of the report (I still ran algorithm against “Play” attribute for “yes” or “no”), I experimented first with Winnow algorithm by Littlestone. I came to find that Balance Winnow would yield better (more accurate) results. I increased it to 10 iterations and set alpha to 5.0. Below is the output:

=== Run information ===

Scheme: weka.classifiers.functions.Winnow -L -I 10 -A 5.0 -B 0.5 -H -1.0 -W 2.0 -S 1

Relation: weather.symbolic

Instances: 14

Attributes: 5

outlook

temperature

humidity

windy

play

Test mode: 10-fold cross-validation

=== Classifier model (full training set) ===

Winnow

Attribute weights

w0 p 3051757.8125 n 3.0517578125 d 3051754.7607421875

w1 p 0.0625 n 6250.0 d -6249.9375

w2 p 596046.4477539062 n 59604.644775390625 d 536441.8029785156

w3 p 10.0 n 1.0 d 9.0

w4 p 745058.0596923828 n 745058.0596923828 d 0.0

w5 p 15258.7890625 n 1525.87890625 d 13732.91015625

w6 p 953.67431640625 n 953674.31640625 d -952720.6420898438

w7 p 2384.185791015625 n 2384185.791015625 d -2381801.6052246094

Cumulated mistake count: 46
Time taken to build model: 0 seconds

=== Stratified cross-validation ===

=== Summary ===

| | | |
|----------------------------------|------------|-----------|
| Correctly Classified Instances | 9 | 64.2857 % |
| Incorrectly Classified Instances | 5 | 35.7143 % |
| Kappa statistic | 0.186 | |
| Mean absolute error | 0.3571 | |
| Root mean squared error | 0.5976 | |
| Relative absolute error | 75 % | |
| Root relative squared error | 121.1306 % | |
| Total Number of Instances | 14 | |

=== Detailed Accuracy By Class ===

| | TP Rate | FP Rate | Precision | Recall | F-Measure | ROC Area | Class |
|---------------|---------|---------|-----------|--------|-----------|----------|-------|
| | 0.778 | 0.6 | 0.7 | 0.778 | 0.737 | 0.589 | yes |
| | 0.4 | 0.222 | 0.5 | 0.4 | 0.444 | 0.589 | no |
| Weighted Avg. | 0.643 | 0.465 | 0.629 | 0.643 | 0.632 | 0.589 | |

=== Confusion Matrix ===

a b <-- classified as

7 2 | a = yes

3 2 | b = no

Here we can see the Balance Winnow neural network algorithm yields greater accuracy than Bayes algorithm.

Below is the experiment with Voted Perceptron. I have set the iteration to 10 which yield the most accurate results, and have the following outputs:

=== Run information ===

Scheme: weka.classifiers.functions.VotedPerceptron -I 10 -E 1.0 -S 1 -M 10000

Relation: weather.symbolic

Instances: 14

Attributes: 5

outlook

temperature

humidity

windy

play

Test mode: 10-fold cross-validation

=== Classifier model (full training set) ===

VotedPerceptron: Number of perceptrons=37

Time taken to build model: 0 seconds

=== Stratified cross-validation ===

=== Summary ===

| | | |
|----------------------------------|------------|-----------|
| Correctly Classified Instances | 10 | 71.4286 % |
| Incorrectly Classified Instances | 4 | 28.5714 % |
| Kappa statistic | 0.3171 | |
| Mean absolute error | 0.2857 | |
| Root mean squared error | 0.5345 | |
| Relative absolute error | 60 % | |
| Root relative squared error | 108.3425 % | |
| Total Number of Instances | 14 | |

=== Detailed Accuracy By Class ===

| | TP Rate | FP Rate | Precision | Recall | F-Measure | ROC Area | Class |
|---------------|---------|---------|-----------|--------|-----------|----------|-------|
| | 0.889 | 0.6 | 0.727 | 0.889 | 0.8 | 0.644 | yes |
| | 0.4 | 0.111 | 0.667 | 0.4 | 0.5 | 0.667 | no |
| Weighted Avg. | 0.714 | 0.425 | 0.706 | 0.714 | 0.693 | 0.652 | |

=== Confusion Matrix ===

a b <-- classified as

8 1 | a = yes

3 2 | b = no

Here we can observe that Vote Perceptron is slightly more accurate than Balance Winnow

For the very last one I tested with Multilayer Perceptron. At first I used the cross-validation method in 10 folds and used default settings:

=== Run information ===

Scheme: weka.classifiers.functions.MultilayerPerceptron -L 0.3 -M 0.2 -N 500 -V 0 -S 0 -E 20 -H a

Relation: weather.symbolic

Instances: 14

Attributes: 5

outlook

temperature

humidity

windy

play

Test mode: 10-fold cross-validation

=== Classifier model (full training set) ===

Sigmoid Node 0

Inputs Weights

Threshold -4.597967080790813

Node 2 2.433270074007239

Node 3 2.0546443732203774

Node 4 1.364159803860347

Node 5 2.6974766889493536

Node 6 3.908322709064356

Sigmoid Node 1

Inputs Weights

Threshold 4.601251960011152

Node 2 -2.4045226373071156

Node 3 -2.0532744956144127

Node 4 -1.379986429753948

Node 5 -2.756274547604192

Node 6 -3.877948258791871

Sigmoid Node 2

Inputs Weights

Threshold -0.1550798021501342

Attrib outlook=sunny -1.323464477913686

Attrib outlook=overcast 1.6602675280399888

Attrib outlook=rainy -0.3207802552865604

Attrib temperature=hot -0.2873122456981835

Attrib temperature=mild 1.181190360097958

Attrib temperature=cool -0.7853150475848826

Attrib humidity 2.808930687905

Attrib windy 1.9190213581350706

Sigmoid Node 3

Inputs Weights

Threshold -0.18031675012278034

Attrib outlook=sunny -1.1524514010228344

Attrib outlook=overcast 1.5760227701429683

Attrib outlook=rainy -0.32578400279223824

Attrib temperature=hot -0.2760307631136823

Attrib temperature=mild 1.0450876279343007

Attrib temperature=cool -0.6318819517738498

Attrib humidity 2.4504774603875408

Attrib windy 1.678251292646871

Sigmoid Node 4

Inputs Weights

Threshold -0.3554146745674961

Attrib outlook=sunny -0.46574052680925143

Attrib outlook=overcast 1.4382073898080827

Attrib outlook=rainy -0.6194183985830608

Attrib temperature=hot -0.0670794406887232

Attrib temperature=mild 0.6337484752708613

Attrib temperature=cool -0.20814280117719502

Attrib humidity 1.982466584793048

Attrib windy 0.9946423645131915

Sigmoid Node 5

Inputs Weights

Threshold -0.06888405078498452

Attrib outlook=sunny -1.3982064219096493

Attrib outlook=overcast 1.8084944112736516

Attrib outlook=rainy -0.31997269602762973

Attrib temperature=hot -0.3035821635771427

Attrib temperature=mild 1.2908528760310662

Attrib temperature=cool -0.8921466424329777

Attrib humidity 3.1090049574873424

Attrib windy 2.0747113212966872

Sigmoid Node 6

Inputs Weights

Threshold 0.04399369934901554

Attrib outlook=sunny -1.80182134279014

Attrib outlook=overcast 2.2544547024444554

Attrib outlook=rainy -0.40095717506501327

Attrib temperature=hot -0.41558677311306397

Attrib temperature=mild 1.589170285947685

Attrib temperature=cool -1.2545441906677217

Attrib humidity 4.119310666164331

Attrib windy 2.740851006387263

Class yes

Input

Node 0

Class no

Input

Node 1

Time taken to build model: 0.04 seconds

=== Stratified cross-validation ===

=== Summary ===

Correctly Classified Instances 10 71.4286 %

| | | |
|----------------------------------|------------|-----------|
| Incorrectly Classified Instances | 4 | 28.5714 % |
| Kappa statistic | 0.3778 | |
| Mean absolute error | 0.287 | |
| Root mean squared error | 0.5268 | |
| Relative absolute error | 60.2616 % | |
| Root relative squared error | 106.7798 % | |
| Total Number of Instances | 14 | |

=== Detailed Accuracy By Class ===

| | TP Rate | FP Rate | Precision | Recall | F-Measure | ROC Area | Class |
|---------------|---------|---------|-----------|--------|-----------|----------|-------|
| | 0.778 | 0.4 | 0.778 | 0.778 | 0.778 | 0.778 | yes |
| | 0.6 | 0.222 | 0.6 | 0.6 | 0.6 | 0.778 | no |
| Weighted Avg. | 0.714 | 0.337 | 0.714 | 0.714 | 0.714 | 0.778 | |

=== Confusion Matrix ===

a b <-- classified as

7 2 | a = yes

2 3 | b = no

Now we can see that the accuracy is the same as Voted Perceptron. However, when I changed the test option to “use training set”, I get the following outputs:

=== Run information ===

Scheme: weka.classifiers.functions.MultilayerPerceptron -L 0.3 -M 0.2 -N 1000 -V 0 -S 0 -E 20 -H a -G -R

Relation: weather.symbolic

Instances: 14

Attributes: 5

outlook

temperature

humidity

windy

play

Test mode: evaluate on training data

=== Classifier model (full training set) ===

Sigmoid Node 0

Inputs Weights

Threshold -5.081857314846875

Node 2 2.6715249490548794

Node 3 2.251760593341115

Node 4 1.4994076214733423

Node 5 2.967210184693087

Node 6 4.2790675652713865

Sigmoid Node 1

Inputs Weights

Threshold 5.084459879999403

Node 2 -2.642796436026053

Node 3 -2.250352131317195

Node 4 -1.5137658697663385

Node 5 -3.0259674310173468

Node 6 -4.248544919362796

Sigmoid Node 2

Inputs Weights

Threshold -0.13873493005732862

Attrib outlook=sunny -1.4492289465127528

Attrib outlook=overcast 1.7898239678319696

Attrib outlook=rainy -0.3409170985722816

Attrib temperature=hot -0.30431851473796845

Attrib temperature=mild 1.2738308601738473

Attrib temperature=cool -0.8772941507137791

Attrib humidity 3.0699255052639662

Attrib windy 2.0960882991257384

Sigmoid Node 3

Inputs Weights

Threshold -0.16835204158970954

Attrib outlook=sunny -1.2764033805115536

Attrib outlook=overcast 1.6868541506421295

Attrib outlook=rainy -0.3246281123357519

Attrib temperature=hot -0.28904343487944056

Attrib temperature=mild 1.1346339039998792

Attrib temperature=cool -0.7203802646067542

Attrib humidity 2.6691876790376585

Attrib windy 1.8390765509232925

Sigmoid Node 4

Inputs Weights

Threshold -0.3954814587660398

Attrib outlook=sunny -0.40299546399504316

Attrib outlook=overcast 1.5716639630193436

Attrib outlook=rainy -0.7755532504099992

Attrib temperature=hot -0.029751346803451522

Attrib temperature=mild 0.6247237812690319

Attrib temperature=cool -0.19637941686209778

Attrib humidity 2.194233688669763

Attrib windy 0.9891304362035512

Sigmoid Node 5

Inputs Weights

Threshold -0.050344895183565226

Attrib outlook=sunny -1.53491686529524

Attrib outlook=overcast 1.9498318155709733
 Attrib outlook=rainy -0.34313881254077766
 Attrib temperature=hot -0.3225030047936306
 Attrib temperature=mild 1.3859980208449227
 Attrib temperature=cool -0.9869101016317672
 Attrib humidity 3.3913398729039885
 Attrib windy 2.275948649841396

Sigmoid Node 6

Inputs Weights

Threshold 0.07266190201339322

Attrib outlook=sunny -1.970031768136808

Attrib outlook=overcast 2.4383308153643095

Attrib outlook=rainy -0.445291065302569

Attrib temperature=hot -0.4441169780836608

Attrib temperature=mild 1.699450039296265

Attrib temperature=cool -1.3649619417100853

Attrib humidity 4.456798775766955

Attrib windy 2.9777160194668197

Class yes

Input

Node 0

Class no

Input

Node 1

Time taken to build model: 3.71 seconds

=== Evaluation on training set ===

=== Summary ===

| | | | |
|----------------------------------|----------|-----|---|
| Correctly Classified Instances | 14 | 100 | % |
| Incorrectly Classified Instances | 0 | 0 | % |
| Kappa statistic | 1 | | |
| Mean absolute error | 0.0151 | | |
| Root mean squared error | 0.0221 | | |
| Relative absolute error | 3.2566 % | | |
| Root relative squared error | 4.6023 % | | |
| Total Number of Instances | 14 | | |

=== Detailed Accuracy By Class ===

| | TP Rate | FP Rate | Precision | Recall | F-Measure | ROC Area | Class |
|---------------|---------|---------|-----------|--------|-----------|----------|-------|
| | 1 | 0 | 1 | 1 | 1 | 1 | yes |
| | 1 | 0 | 1 | 1 | 1 | 1 | no |
| Weighted Avg. | 1 | 0 | 1 | 1 | 1 | 1 | |

=== Confusion Matrix ===

a b <-- classified as

9 0 | a = yes

0 5 | b = no

This yielded 100% accuracy! Of course I trained the data and modeled itself. So it is probably over trained. By the looks of it, using the option “using training set” would yield more accurate results than cross-validation 10 folds

Data Table:

| | AODE | Batyes Net | Naïve Bayes | Balanced Winnow | Voted Perceptron | Multilayer Perceptron |
|----------|------|---------------|-------------|-----------------|------------------|-----------------------|
| Accuracy | 50 | 57 | 57 | 64 | 71 | 71 |

Graph for Cross-Validation 10 Fold:

